

On the Variation of Light Intensity in the Solar Corona at the Eclipse of 1922, September 21, at Wallal, by Professor A. D. Ross, M.A., D.Sc., F.R.S.E.

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Determination of the law of variation of light intensity in the corona is important in the study of the constitution of this solar appendage. Attempts to apply photometric methods at total eclipses date from 1870, December 22, when Professor Pickering used a bunsen photometer in this work.* At the eclipse of 1878, July 29, Professor J. W. Langley attacked the problem with greater success.† But, while Professor T. E. Thorpe and Sir William Abney continued the tests at the eclipses of 1886, August 29‡, and 1893, April 16§, little real progress was made until standardised photographic plates were introduced by Abney. In this method part of a plate to be used on the corona was previously impressed with a series of standard squares by photographing an artificial light through sheets of varying and known thickness of some translucent material. In this way there was obtained on the negative a scale of image densities corresponding with definite relative light intensities. These squares were first used at the eclipse of 1889, December 22, but the resulting plates do not appear to have been measured. Further plates were secured at the eclipse of 1893, April 16, and were examined by Professor H. H. Turner.* These several investigations appeared to show that the intensity of the light varied inversely as the square of the distance from the sun's limb, although the visual and photographic tests revealed very considerable discrepancies.

At the eclipse of 1922, September 21, the author decided to carry out a series of tests using two cameras of about 75 cms. focal length, the lenses being operated at $f/10$. These gave solar discs of about 7 mms. diameter, and the total space occu-

* U. S. Coast Survey Reports, 1870, p. 172.

† Washington Observations, 1876, appendix III.

‡ Phil. Trans. Roy. Soc., A. clxxx (1889), p. 361.

§ Phil. Trans. Roy. Soc., A. clxxxvii (1896), p. 433.

* Proc. Roy. Soc., lxvi (1900), p. 403.

pied by the corona and its streamers was about 3 cms. The cameras were mounted on the same polar axis as carried the Floyd telescope and spectroscopes of the Lick Observatory, and, as the author had to operate the latter instruments at the beginning and end of totality, the arrangement facilitated rapid working. Some trouble was experienced in obtaining sharp definition. The cameras were focussed at night by photographing stars, but it was evident that temperature and humidity affected the adjustment to a slight degree. In the end one camera gave perfect focus, but while the other was very slightly out of focus the result was to soften the structure apparent in the coronal streamers and so assisted in getting average values more readily.

The plates employed were Ilford Special Rapid and Wellington Antiscreen. Half-plates were cut in two, one portion to be used in photographing the corona and the other half to receive standardisation. The standard squares were obtained by exposing to a fixed light at varying distances successive portions each about 2 cms. square of each plate for the same period as was to be given to the corresponding eclipse photograph. For the fixed light an amyl acetate lamp was enclosed in a well-ventilated box with a hole 2 mms. in diameter, 25 mms. above the top of the wick, and 32 mms. in front of the flame. The flame was adjusted by the lamp microscope to the customary height of 40 mms. The standard squares were impressed by exposing the sections of the plate to the light at distances of 100, 141, 200, 283, 400, and 566 cms., this giving exposure intensities of 1, $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, 1-16, and 1-32. These standard squares were photographed about twelve hours before the eclipse, but the plates were not developed until three to four weeks later. As experience with other plates used at the eclipse made it probable that the squares were under-exposed, a second series was impressed on the actual eclipse plates. These carried the series three terms further on the side of greater intensity. The results thoroughly justified this step, and the second series gave a completely satisfactory set of standards. Comparison with the earlier series showed that no appreciable error was introduced by the lapse of time between the eclipse photographs and the photographs of the second series made immediately before development.

Three plates were exposed in each camera, two Ilford Special Rapid and one Wellington Antiscreen plates in one camera and two Wellington Antiscreen and one Ilford Special Rapid plates in the other. In each case two plates of different type were given a shorter exposure, and the remaining plate a four-fold longer exposure.

A simple optical arrangement was devised by which two standard squares and any desired portion of a coronal photograph could be brought into juxtaposition in the field of view of a low power compound microscope, and so the intensities at selected points beyond the solar limb could be compared.

The results may be summarised as follows:

1. The inverse relation of intensity of light to the square of the distance from the sun's limb holds approximately for distances exceeding 0.2 solar radii when Ilford Special Rapid Plates are used.

2. The inverse square law is more accurate at considerable distances from the limb than near the limb. Close to the limb the intensity does not diminish so rapidly as according to the inverse square law.

3. With the Wellington Antiscreen Plates the falling off in intensity is much more gradual than according to an inverse square law, varying approximately as d to the power $-3/2$, where d is the distance from the limb in solar radii.

4. The rates of variation are nearly the same in all directions, the slight deviations noted being that the intensity falls off less rapidly along equatorial than along polar radii, and less rapidly along the principal streamers than along radii clear of the streamers.

It appears desirable that similar investigations should be made at several eclipses during the sunspot cycle, and the results obtained discussed along with measurements of the total light intensity of the corona.*

The author desires to express his indebtedness to Mr. W. H. Crocker of San Francisco and to Dr. W. W. Campbell of the Lick Observatory for facilities for carrying out the above tests at Wallal.

* G. H. Briggs, *Astrophysical Jour.*, lx, No. 5, p. 273 (1924), and A. D. Ross, *Monthly Notices Roy. Astron. Soc.*, lxxxiv, p. 660 (1924).

